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Indian Standard

METHODS OF MEASUREMENT OF ELECTRICAL CHARACTERISTICS OF MICROCIRCUITS

PART II ANALOGUE MICROCIRCUITS

UDC 621·3·049·77 : 621·317·3

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Price Rs 16·00 [redacted] Gr 9

October 1980

Indian Standard

METHODS OF MEASUREMENT OF ELECTRICAL CHARACTERISTICS OF MICROCIRCUITS

PART II ANALOGUE MICROCIRCUITS

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Indian Standard

METHODS OF MEASUREMENT OF ELECTRICAL CHARACTERISTICS OF MICROCIRCUITS

PART II ANALOGUE MICROCIRCUITS

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 11 April 1980, after the draft finalized by the Semi-conductor Devices and Integrated Circuits Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard, dealing with the methods of test for microcircuits, has been prepared in two parts. The first part deals with digital microcircuits and the second part deals with analogue microcircuits.

0.3 The measurements and conditions are so specified as to achieve the required degree of accuracy. Additional test methods such as pulse methods have also been given which will give compatible results. By ' compatible ', it is meant that the value of the characteristic will fall within specified limits as for other methods when measured under specified condition.

0.4 While preparing this standard, assistance has been derived from the following:

IEC Pub 147-2 Essential ratings and characteristics of semiconductor devices, and general principles of measuring methods. International Electrotechnical Commission (IEC).

BS 9400 : 1970 Integrated electronic circuits of assessed quality: Generic date and methods of test. British Standards Institution.

JSS 51400 (Part II) Test methods for microcircuits. Ministry of Defence, Government of India.

0.5 In reporting the results of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part II) describes the methods of measurement of electrical characteristics for testing of analogue microcircuits.

2. TERMINOLOGY AND LETTER SYMBOLS

2.1 Terminology — For the purpose of this standard, the terms and definitions given in IS : 1885 (Part VII/Sec 5)-1971* shall apply.

2.2 Letter Symbols — For letter symbols, reference shall be made to IS : 3715-1971†.

3. GENERAL CONDITIONS

3.1 Unless otherwise stated, all tests shall be made under standard atmospheric conditions as specified in **3.1** of IS : 6553-1971‡. Before the measurements are made, the microcircuit shall be stored at the measuring temperature for a time sufficient to allow the entire circuit to reach this temperature. The recovery period specified shall also be sufficient for this purpose. When measurements are made at a temperature other than that specified, the ambient temperature during the measurement shall be recorded and the results shall be corrected, where necessary, to the specified temperature.

During measurements, the microcircuits shall not be exposed to draughts or direct sun-rays, and shall be protected from radio-active and electromagnetic radiations.

3.2 Electrical Test Conditions

3.2.1 *Ratings* — The test conditions for all measurements should be such that the maximum ratings of the device are not exceeded.

The precautions should include limits on maximum instantaneous currents and applied voltages. Devices should neither be inserted into, nor removed from a test circuit while the latter is energized.

3.2.2 *Equilibrium Conditions* — All electrical tests shall be conducted under equilibrium conditions unless otherwise specified or unless the measurement is being carried out under pulsed conditions. When test conditions cause significant change with time of the characteristic being measured, means of compensation for such effects will be specified; for example, the time duration that the device shall be maintained at test conditions before making a measurement.

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*Electrotechnical vocabulary: Part VII Semiconductor devices, Section 5 Integrated circuits and microelectronics.

†Letter symbols for semiconductor devices.

‡Environmental requirements for semiconductor devices and integrated circuits.

3.2.3 *Temperature*

a) Unless otherwise specified, all electrical measurements shall be made at an ambient or reference point temperature of 25 ± 3°C. Measurements may be carried out at temperatures other than 25°C provided, that the device will be in accordance with all the provisions of the detail specification when tested at 25°C.

b) The ambient temperature shall be measured as the air temperature below the microcircuit in an environment of substantially uniform temperature, cooled only by natural air convection and not materially affected by reflective and radient surfaces.

c) The reference point temperature for case-rated microcircuits intended for conduction cooling through a mounting base shall be measured in accordance with the method given in Appendix A.

d) For circuits specified to be used under conditions other than ambient or condition cooling, the temperature shall be measured as required by the detail specification.

3.2.4 *Measurement Circuit Requirements and Precautions*

a) *Open-circuit* — A circuit shall be considered open-circuited if a two-to-one decrease in the terminating impedance does not produce a change in the parameter being measured that is greater than the required accuracy of measurement. The values of high resistances (whether of circuit components or meters) specified in the circuits, should be so high that a two-to-one decrease in their value shall not effect the desired accuracy of the measurement.

b) *Short-circuit* — A circuit shall be considered short-circuited if a two-to-one increase in the terminating impedance does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement. Capacitors used to couple or by-pass the test signal should present effective short-circuits at the test frequency. In certain of the high-frequency measurements, where rf decoupling is important, the necessary components or mounting conditions or both of the device shall be as specified.

c) *Small-signal* — A signal shall be considered small if a two-to-one change in its magnitude does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement. Care should be taken that the measuring equipment does not introduce spurious oscillation or distortion likely to affect the required accuracy of measurement.

d) *Constant current source* — A current source shall be considered constant if a two-to-one increase of a load impedance (*see* Note) does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement.

e) *Current measuring device* — The effective admittance of a current measuring device shall be sufficiently high so that halving its value does not significantly affect the accuracy of the test.

f) *Constant voltage source* — A voltage source shall be considered constant if a two-to-one decrease of a load impedance (*see* Note) does not produce a change in the parameter being measured that is greater than the required accuracy of measurement.

g) *Voltage measuring device* — The effective impedance of a voltage measuring device shall be sufficiently high so that halving its value does not significantly affect the accuracy of measurement.

NOTE — A load in the conditions (d) and (f) is chosen to represent the equivalent resistance of the test circuit and unit under test. For acceptance test purposes, the resistor value should represent the limiting conditions.

3.2.5 *Power Supplies* — The sources of direct currents and voltages should not have ripple contents large enough to affect the desired accuracy of measurement. Test or supply voltages or currents shall be within ± 1 percent of the specified value.

3.2.6 *Accuracy of Measurement* — The limits quoted in detail specifications are absolute. Tolerance on measurements shall be taken into account when determining the actual measurement limits.

3.2.7 *Multiple Input/Output Devices* — Each functionally independent section of a multiple input/output devices shall be tested individually and all terminals associated solely with sections not under test shall be left open-circuit, or as specified.

Each of a group of functionally equivalent signal terminals shall be tested individually, with connections as specified in the detail specification applied to the remainder.

4. GENERAL PRECAUTIONS

4.1 Care should be taken to ascertain that no parasitic oscillations occur during any measurement.

4.2 Any auxiliary or stabilizing circuits shall be connected as specified.

4.3 All power supplies should have essentially zero impedance to the signal frequencies used in the tests.

4.4 To confirm that testing is being carried out on a linear part of the microcircuit characteristic, the signal input should be reduced by 6 dB and the output checked for a similar reduction of 6 dB.

4.5 The ambient or reference point temperature shall be within ± 2°C of the specified value during all tests unless otherwise stated.

4.6 When the microcircuit under test is connected to or disconnected from the testing circuit, care shall be taken that the limiting conditions of use are not exceeded during such processes.

> NOTE — In certain tests (for example offset voltage and current) the specified characteristics imply measurement at the input of the amplifier. The methods use measurements made at the output using the gain of the amplifier to reduce the effect of impedance on the measurement point.

5. INPUT OFFSET VOLTAGE

5.1 Purpose — To measure the continuous (direct) voltage required between the input terminals of a differential amplifier to give a reference output voltage, usually zero.

5.2 Circuit — The circuit as shown in Fig. 1 shall be used.

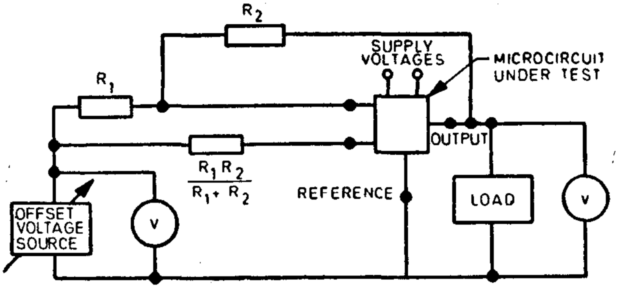


FIG. 1 CIRCUIT FOR MEASUREMENT OF INPUT OFFSET VOLTAGE

5.3 Description — The apparatus shall consist of a suitable dc voltmeter and precision resistors. In the case of single input non-inverting amplifier an inverting amplifier shall also be required. The value of resistor R_2 should be selected to be not larger than the nominal input impedance nor less than ten times the value of the nominal output impedance of the amplifier. The value of resistor R_1 should be equal to that of resistor R_2 divided either by 100 or by one-tenth of the open-loop gain, whichever gives the larger value.

The impedance of the input offset voltage source shall be low enough to ensure less than 1 percent error due to maximum specified offset current compared with maximum specified offset voltage.

5.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement.

The microcircuit is inserted into the test socket in accordance with its markings and the supply voltages are set to their specified values.

The offset voltage source is adjusted to bring the output level of the amplifier to zero or the specified reference voltage. The offset voltage (V_{IO}) of the amplifier is equal to:

$$V_{IO} = \frac{R_1}{R_1 + R_2} (V_{ref} - V_1)$$

where

V_{ref} = specified reference output voltage,
V_1 = voltage of the offset voltage source,
R_1 = value of R_1, and
R_2 = value of R_2.

5.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages;
b) Values of R_1, R_2 and output lead impedance;
c) Details of any additional circuits to be connected externally;
d) Output reference voltage level (if not zero); and
e) Ambient or reference point temperature.

6. INPUT OFFSET CURRENT

6.1 Purpose — To measure the difference between the input currents of a differential amplifier to give a reference output voltage, usually zero.

6.2 Circuit — The circuit as shown in Fig. 2 shall be used.

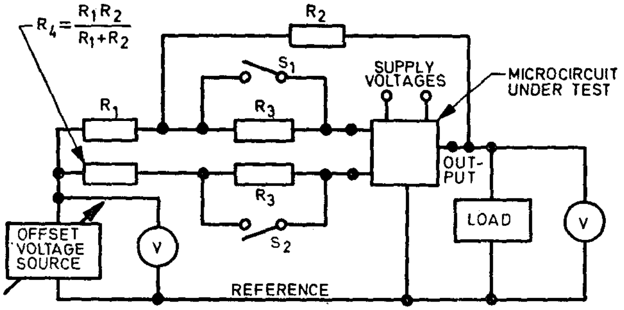


FIG. 2 CIRCUIT FOR MEASUREMENT OF INPUT OFFSET CURRENT

6.3 Description — The apparatus shall consist of a suitable dc voltmeter and precision resistors. In case of single input non-inverting amplifiers, an inverting amplifier shall also be required. The object of the method is to note the effect of inserting a known resistance in each input lead on the balance of amplifier, and then to obtain a value for input offset current by calculation.

The value of R_2 should not be greater than the nominal input impedance of the amplifier nor less than ten times the value of the nominal output impedance. R_1 should be equal to R_2 divided either by 100 or by one-tenth the open-loop gain, whichever gives the larger value.

R_3 should not be greater than the nominal input impedance of the amplifier.

The impedance of the offset voltage source shall be low enough to ensure less than 1 percent error.

6.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement. The microcircuit is inserted into the test circuit and the supply voltages are adjusted to be within 1 percent of their specified values.

With switches S_1 and S_2 closed, the offset voltage supply is adjusted until the output voltage indicated is zero (or the specified reference value). Let this value of the output of the offset voltage source be V_1. Switches S_1 and S_2 are now opened, and the offset voltage supply readjusted to bring the output voltage back to its reference value. Let the new value of the offset voltage source be V_2, then the

$$\text{Input offset current} = \frac{R_1}{R_3\,(R_1 + R_2)}(V_1 - V_2)$$

where

R_1, R_2 and R_3 are the respective values of resistors R_1, R_2 and R_3.

6.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages;
b) Values for R_1, R_2 and R_3 and output load;
c) Details of any additional circuits to be connected externally;
d) Output voltage reference level; and
e) Ambient or reference point temperature.

7. INPUT BIAS VOLTAGE

7.1 Purpose — To measure the input bias voltage of a linear amplifier microcircuit under specified conditions.

7.2 Circuit — The circuit as shown in Fig. 3 shall be used.

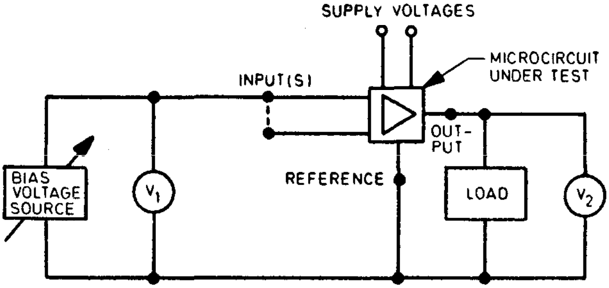


FIG. 3 CIRCUIT FOR MEASUREMENT OF INPUT BIAS VOLTAGE

7.3 Description — The measurement shall be made with each supply voltage set to the specified value and with a specified terminating impedance at the output terminal. The input bias voltage is connected to a specified input terminal of a single ended amplifier, or to the inverting and non-inverting input terminals connected together for a differential amplifier.

7.4 Procedure — Temperature conditions are set to the specified value and checked before and after the measurement.

The microcircuit is inserted into the test socket in accordance with its markings and the supply voltages are set to their specified values. The bias voltage supply is adjusted until the steady state output voltage as recorded by the meter V_2 attains the specified reference value. The input bias voltage is recorded on meter V_1.

All voltage supplies are reduced to zero and the microcircuit removed from the test circuit.

NOTE — For a differential amplifier having a high value of offset voltage, it may be found impracticable to obtain a measurement of input bias voltage.

7.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages,
b) Output load,
c) Details of any additional circuits to be connected externally,
d) Reference value of output voltage, and
e) Ambient or reference point temperature.

8. INPUT BIAS CURRENT

8.1 Purpose — To measure the input bias current of a linear amplifier microcircuit under specified conditions.

8.2 Circuit — The circuit as shown in Fig. 4 shall be used.

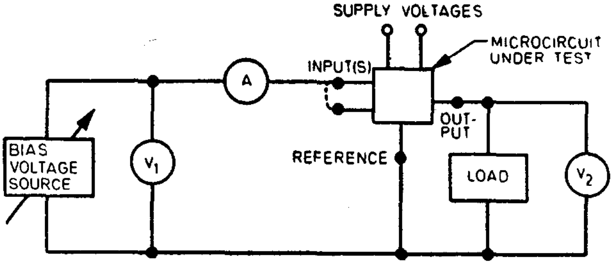


FIG. 4 CIRCUIT FOR MEASUREMENT OF INPUT BIAS CURRENT

8.3 Description — The apparatus shall consist of a suitable dc voltmeter and precision resistors. In the case of single input non-inverting amplifiers, an inverting amplifier shall also be required. The input bias voltage is set up according to the procedure given in **7**. The input bias current is recorded on ammeter *A*.

All the precautions given in **7** apply also to this measurement.

8.4 Information to be Given in the Relevant Detail Specifications:

a) Supply voltages,
b) Output load,
c) Reference value of output voltage, and
d) Ambient or reference point temperature.

9. OUTPUT VOLTAGE SWING

9.1 Purpose — To measure the range of output voltage of an amplifier between its overload points under specified conditions.

9.2 Circuit — The circuit as shown in Fig. 5 shall be used.

9.3 Description — With zero input signal, the mean level of the output voltage is set to the mid-point of the specified range of output voltage by adjustment of the offset voltage source. The input signal amplitude is then adjusted to give a reference value of peak-to-peak output signal equal to 5 percent of the minimum specified output voltage swing.

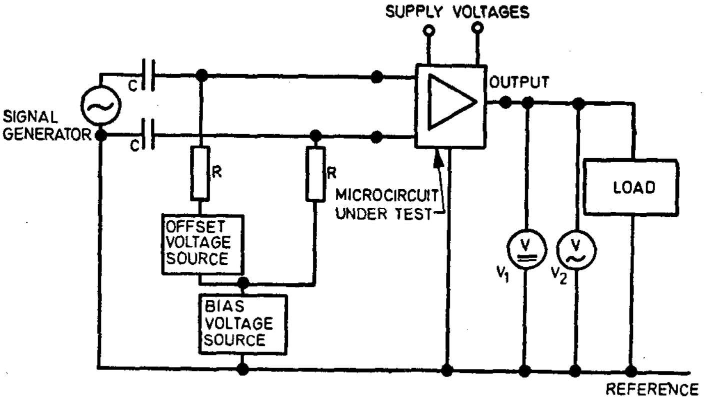


FIG. 5 CIRCUIT FOR MEASUREMENT OF OUTPUT VOLTAGE SWING

Keeping the input signal amplitude constant, the mean level of the output voltage is varied by further adjustment of the offset voltage source. The overload points occur at those mean output levels where the output signal amplitude falls to 50 percent of its initial reference value.

The value of each of the resistors R_1 should be equal to the minimum value of the resistive component of the input impedance of the amplifier. Where the microcircuit has a single ended input with one side taken to the zero (or reference) line, only one resistor is required.

The two capacitors should offer negligible impedance at the specified frequency of the signal for the test, that is, the capacitor impedance should be less than one hundredth of the input impedance.

Voltmeter V_2 should be a peak reading instrument.

The measurement shall be made under specified conditions of maximum specified supply voltage, output loading and operating frequency. The bias voltage shall be zero unless otherwise specified.

Other inputs and connections to other amplifiers in a multiple amplifier circuit, shall be left open-circuited or as specified.

9.4 Procedure — The temperature conditions are set to the specified values and checked before and after the measurement.

The microcircuit is inserted into the test circuit in accordance with its markings. The supply and bias voltages are set to their specified values, The mean output voltage level V_1 (indicated on voltmeter V_1), with zero input signal, is adjusted by variation of the offset voltage source (bias voltage for single input amplifiers), until it attains the value 0·5 ($A + B$), where A and B are the specified limits of the range of output voltage.

The input is then adjusted to give the reference output amplitude (indicated on voltmeter V_2), that is, 0·05 ($A - B$) volts peak-to-peak.

The mean level of the output voltage is altered first in one direction, then the other, until the output signal amplitude is halved. The values then indicated on voltmeter V_1 are recorded. The difference between these values is the output voltage swing.

9.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages,
b) Input signal frequency,
c) Output load,
d) Details of any additional circuits to be connected externally, and
e) Ambient or reference point temperature.

10. OUTPUT PERFORMANCE (POWER DISSIPATION)

10.1 Purpose — To measure the power dissipation of a device under test.

10.2 Circuit — The circuit as shown in Fig. 6 shall be used.

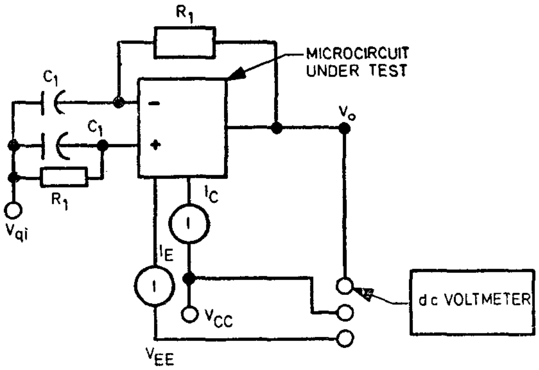


FIG. 6 CIRCUIT FOR MEASUREMENT OF POWER DISSIPATION

10.3 Description — The apparatus will consist of a signal generator, dc ammeter, dc voltmeter, resistors and capacitors.

Unless otherwise specified, all the parameters shall be measured at the minimum and maximum specified operating temperature and at 25°C ambient.

10.4 Procedure — R_1 should be no larger than the nominal input impedance nor less than a value which will load the amplifier ($100 \times Z_{out}$), and $2 \pi f R_1 C_1$ shall be at least 10 A_d where A_d is the open-loop gain and f is the test frequency.

The positive supply voltage and current V_{CC} and I_C and the negative supply voltage and current V_{EE} and I_E shall be measured. The power dissipation $Pd = V_{CC} I_C + V_{EE} I_E$ shall be calculated.

10.5 Information to be Given in the Relevant Detail Specification:

a) Values of R_1 and C_1,

b) Pd maximum,

c) V_{o1} at the specified temperature, and

d) Test temperatures.

11. SUPPLY VOLTAGE REJECTION RATIO

11.1 Purpose — To measure the rejection factor of a microcircuit amplifier to a change in supply voltage. The methods may be used for either a single input amplifier or a differential input amplifier.

11.2 Circuit

11.2.1 For an amplifier having a single input, the circuit of Fig. 3 shall be used.

11.2.2 For an amplifier having differential inputs, the circuit of Fig. 1 shall be used.

11.3 Description — The apparatus shall consist of a suitable signal generator, ac voltmeters, power supply, low pass filter, capacitors and precision resistors.

11.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement.

The microcircuit is inserted into the appropriate test circuit in accordance with its markings.

All the requirements of **5** and **7** (for example in respect of source impedance, accuracy of supply voltages, values of circuit resistors, etc) shall be observed.

With specified value(s) of supply voltage(s), the bias voltage (for a single input amplifier) or input offset voltage (for a differential input amplifier) is measured and its value noted.

Each supply voltage is then increased by a specified amount, and the bias or input offset voltage; as appropriate, is adjusted to restore the output voltage to its original reference level. The new-level of bias voltage (or input offset voltage), is noted.

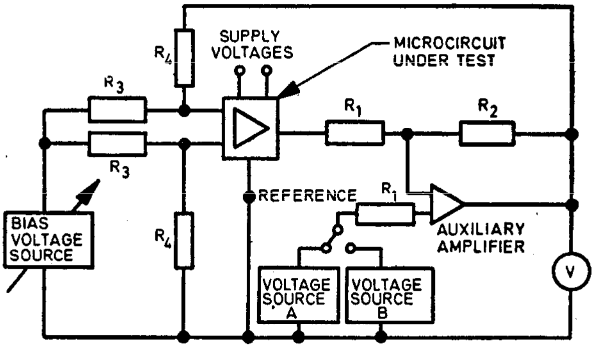
The supply voltage rejection ratio is the ratio of the change in supply voltage to the resulting change in bias voltage (or input offset voltage).

11.5 Information to be Given in the Relevant Detail Specification — The conditions shall be the same as those given in **5.5** and **7.5** and in addition, the magnitude of the increase (or decrease) of the supply voltage.

12. DIFFERENTIAL INPUT OPERATING VOLTAGE

12.1 Purpose — To measure the differential input operating voltage of a differential comparator microcircuit under dc conditions at each end of the bias range.

12.2 Circuit — The circuit as shown in Fig. 7 shall be used.



NOTE — The output of voltage source *A* is equal to V_{OL} and *B* is equal to V_{OH}.

FIG. 7 CIRCUIT FOR MEASUREMENT OF DIFFERENTIAL INPUT OPERATING VOLTAGE

12.3 Description — The test circuit is closed-loop system comprising the circuit under test and an auxiliary high gain differential amplifier. The gain of this auxiliary amplifier stage is set at 100 by suitable choice of resistors R_1 and R_2 which should be of high precision and high stability.

Resistor R_3 should have low value in order to avoid errors due to offset current. Resistor R_4 should have values much greater than R_3. Both sets of resistors should be of high precision and stability and should be accurately matched. The value of resistor R_4 should be very much greater than the output impedance of the auxiliary amplifier.

The bias voltage source and the voltage sources *A* and *B* should have very low impedances.

12.4 Procedure — The temperature conditions are set to the specified values and checked before and after the measurement.

The microcircuit is connected into the test circuit in accordance with its markings and the supply voltages are set to within 1 percent of the specified values.

The specified values of bias voltage and V_{OH} are applied and the value of output voltage is measured [$V_{o(1)}$].

The test is repeated with V_{OL} applied, and the value of the output voltage is measured [$V_{o(2)}$].

The differential input operating voltage is then derived from:

$$V_{o(1)} - V_{o(2)} \frac{R_3}{R_4}$$

where

R_3 and R_4 are the respective values of resistors R_3 and R_4.

The test is repeated over the specified range of bias voltages.

12.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages,
b) Range of bias voltages,
c) Values of V_{OL} and V_{OH},
d) Details of any additional circuits to be connected externally, and
e) Ambient or reference point temperature.

13. TEMPERATURE COEFFICIENT OF INPUT OFFSET VOLTAGE

13.1 Purpose — To measure the temperature coefficient of input offset voltage over the specified temperatures.

13.2 Circuit — The circuit as shown in Fig. 8 shall be used.

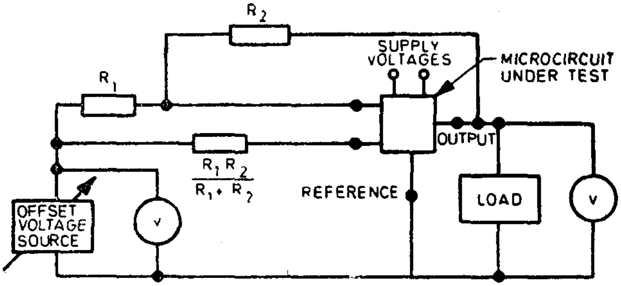


FIG. 8 CIRCUIT FOR MEASUREMENT OF TEMPERATURE COEFFICIENT OF INPUT OFFSET VOLTAGE

13.3 Description — The method 5 of measurement of input offset voltage given in **5**, is used at two specified temperatures t_1 and t_2. However, since the voltage difference to be measured is likely to be small, an accurate high impedance method of measuring voltage shall be used. In addition the temperature shall be accurately controlled during the measurement.

13.4 Procedure — The input offset voltage is measured at two specific values of ambient or reference point temperature t_1 and t_2. The temperature coefficient is calculated from:

$$\frac{V_{IO}(1) - V_{IO}(2)}{t_1 - t_2}$$

13.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages;

b) Values of R_1, R_2 and output load;

c) Details of any additional circuits to be connected externally; and

d) Ambient or reference point temperatures.

14. TEMPERATURE COEFFICIENT OF INPUT OFFSET CURRENT

14.1 Purpose — To measure the temperature coefficient of input offset current at specified temperature.

14.2 Circuit — The circuit as shown in Fig. 9 shall be used.

14.3 Description — The method 6 of measurement of input offset current given in **6**, is used at two specified temperatures t_1 and t_2. However, since the current difference to be measured is likely to be small, an accurate high impedance method of measuring voltage shall be used. In addition the temperature shall be accurately controlled during the measurement.

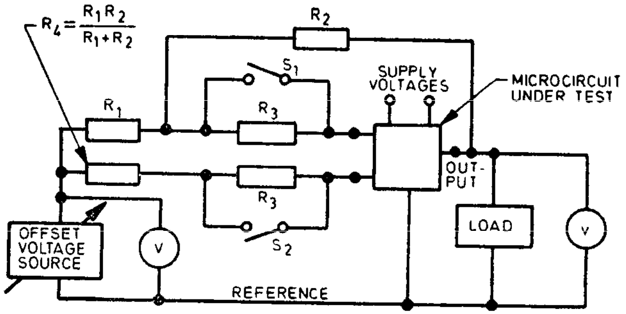


FIG. 9 CIRCUIT FOR MEASUREMENT OF TEMPERATURE COEFFICIENT OF INPUT OFFSET CURRENT

14.4 Procedure — The input offset current is measured at two specified values of ambient or reference point temperature t_1 and t_2. The temperature coefficient is calculated from:

$$\frac{I_{IO}(1) - I_{IO}(2)}{t_1 - t_2}$$

14.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages;

b) Values of resistors R_1, R_2, R_3 and load impedance;

c) Details of any additional circuits to be connected externally;

d) Output reference voltage level; and

e) Ambient or reference point temperature.

15. LOW-STATE STROBE (GATE) CURRENT

15.1 Purpose — To measure the low-state input current to the strobe or gate input of an amplifier under specified conditions.

15.2 Circuit — The circuit as shown in Fig. 10 shall be used.

15.3 Description — The measurement shall be made under maximum specified supply voltage conditions. The output shall be open circuit unless otherwise specified.

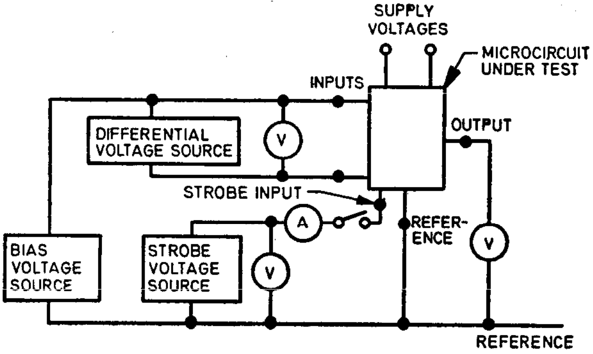


FIG. 10 CIRCUIT FOR MEASUREMENT OF LOW-STATE STROBE (GATE) CURRENT

The specified maximum value of the strobe (gate) low voltage shall be applied to the strobe (gate) input.

The bias voltage shall be zero unless otherwise specified.

For measurement of strobe current only, a specified differential signal voltage of appropriate polarity and sufficient magnitude shall also be applied to ensure maximum cut-off of the signal amplifying path through the strobe circuit. This will be achieved if the amplifier output voltage with the strobe input open-circuit is at the opposite limit to that which occurs when the strobe low voltage is applied to disable the amplifier. Inputs and connections to other amplifiers in a multiple amplifier circuit shall be left open-circuited or as specified.

15.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement. The microcircuit is inserted into the test circuit. The supply, bias and differential input voltages are set to their specified values and the low-state strobe (gate) current measured. The voltages are returned to zero and the microcircuit removed from the circuit.

15.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages,
b) Differential input signal voltage and polarity,
c) Low-state strobe (gate) voltage, and
d) Ambient or reference point temperature.

16. HIGH STATE STROBE (GATE) CURRENT

16.1 Purpose — To measure the high-state input current to the strobe or gate input of an amplifier under specified conditions.

16.2 Circuit — The circuit as shown in Fig. 11 shall be used.

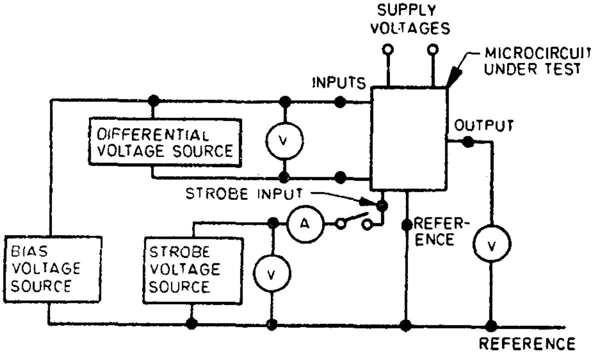


FIG. 11 CIRCUIT FOR MEASUREMENT OF HIGH-STATE STROBE (GATE) CURRENT

16.3 Description — The measurement shall be made under maximum specified supply voltage conditions. The output shall be open-circuited unless otherwise specified.

The specified minimum value of the strobe (gate) high voltage shall be applied to the strobe (gate) input. The bias voltage shall be zero unless otherwise specified.

For measurement of strobe current only, a specified differential signal voltage of appropriate polarity and sufficient magnitude shall also be applied to ensure maximum conduction of the signal amplifying path through the strobe circuit. This will be achieved if the amplifier output voltage with the strobe input open-circuit is at the same limit as that which occurs when the strobe high voltage is applied to disable the amplifier. Inputs and connections to other amplifiers in a multiple amplifier circuit shall be left open-circuit or as specified.

16.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement. The microcircuit is inserted into the test circuit. The supply, bias and differential input voltages are set to their specified values and the high-state strobe (gate) current is measured. The voltages are returned to zero and the microcircuit removed from the circuit.

16.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages,

b) Differential input signal voltage and polarity,

c) High-state strobe (gate) voltage, and

d) Ambient or reference point temperature.

17. AUTOMATIC GAIN CONTROL RANGE

17.1 Purpose — To establish the means for measuring the automatic gain control range of a linear amplifier.

17.2 Circuit — The circuit as shown in Fig. 12 shall be used.

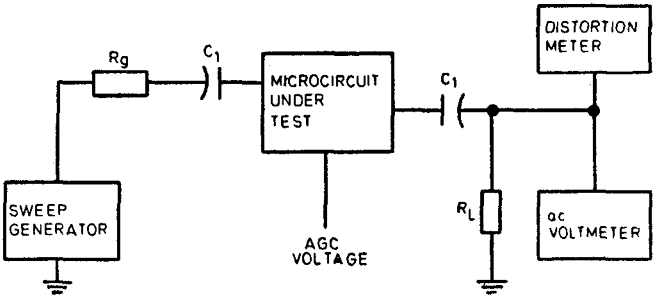


FIG. 12 CIRCUIT FOR MEASUREMENT OF AUTOMATIC GAIN CONTROL RANGE

17.3 Description — The apparatus shall consist of sweep generator, voltage source, resistors, capacitors, an ac voltmeter, and a distortion analyzer.

17.3.1 *Sweep Generator* — The sweep generator must cover the frequency range of the amplifier under test. It shall have an adjustable output level which is flat over the sweep range. It shall be capable of single frequency operation.

17.3.2 *Voltage Source* — The voltage source shall be capable of supplying the specified AGC voltages to the test circuit. The voltage source shall be free of noise or ripple at its outputs.

17.3.3 *Capacitors and Resistors* — The capacitors and resistors shall be within 1 percent or better of the specified values and stable over the test temperature range.

17.3.4 *AC Voltmeter* — The ac voltmeter shall be capable of measuring the amplifier output voltage without loading and shall have a frequency range that will cover the amplifier under test.

17.3.5 *Distortion Analyzer* — The distortion analyzer or meter shall be usable over the passband of the amplifier and shall not load the amplifier.

Unless otherwise specified, all parameters shall be measured at the minimum and maximum specified ambient operating temperature and at 25°C ambient.

17.4 Procedure — The test circuit shown in the above figure shall be used for this test. R_L and C_1 shall be selected to properly load and decouple the circuit, respectively. The AGC voltage shall be set for maximum gain. The input signal is applied (constant frequency) and increased until the output exhibits maximum allowable distortion. The generator is swept over the prescribed range and the bandwidth shall be recorded.

The AGC voltage is varied over the specified range and the reduction in gain shall be measured. The above measurements shall be repeated and the bandwidth and signal handling capability shall be recorded.

17.5 Information to be Given in the Relevant Detail Specification:

a) AGC range;

b) Test frequency range;

c) Increase in bandwidth over the AGC range;

d) Maximum reduction in output impedance, where applicable;

e) Minimum reduction in input signal capability, where applicable;

f) Any other variations when applicable, such as power variation, overloading, limitations as to linearity of gain response *versus* AGC voltage, etc;

g) Test temperature(s); and

h) C_1 and R_L.

18. OPEN-LOOP SMALL-SIGNAL VOLTAGE AMPLIFICATION OF A DIFFERENTIAL AMPLIFIER

18.1 Purpose — To measure the open-loop small-signal voltage amplification of microcircuit differential amplifier at a specified frequency.

18.2 Circuit — The circuit as shown in Fig. 13 shall be used.

18.3 Description — The value of each of the resistors R should be equal to the minimum value of the resistive component of the input impedance of the amplifier.

The capacitor C should offer negligible impedance at the test frequency, that is, less than one hundredth of the input impedance.

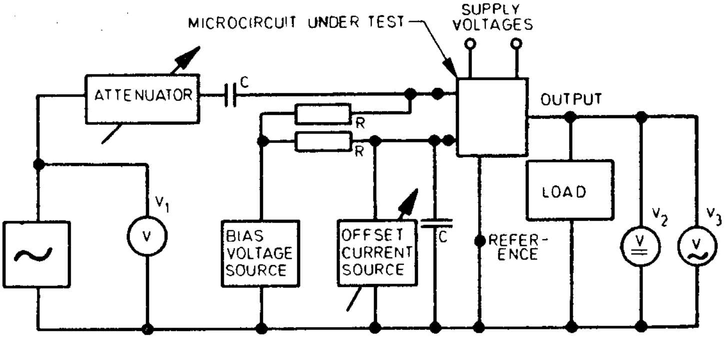


FIG. 13 CIRCUIT FOR MEASUREMENT OF OPEN-LOOP SMALL-SIGNAL VOLTAGE AMPLIFICATION OF A DIFFERENTIAL AMPLIFIER

The output impedance of the attenuator should be very low compared to the input impedance of the microcircuit (including any associated biasing network), that is preferably less than one-hundredth of the input impedance, or suitable matching arrangements shall be used and taken into account.

Voltmeters V_1 and V_3 may be replaced by a single meter with a suitable switching system.

18.4 Procedure — The temperature conditions are set to the specified values and checked before and after the measurement.

The microcircuit is inserted into the test circuit in accordance with its markings, and the supply voltage set to within 1 percent of the specified values.

The offset current source is adjusted so that the quiescent level of the output voltage as indicated by V_2 is maintained at the required reference value.

With the attenuator adjusted to give maximum attenuation, the output voltage of the signal generator is adjusted at the required frequency to be equal to the specified reference value of alternating output voltage, which is usually 10 percent or less of the maximum output voltage swing.

The attenuation is then decreased to provided the specified reference value of alternating voltage at the output of the amplifier.

The voltage amplification is then equal to the value of the attenuation.

18.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages;
b) Output reference voltages, both ac and quiescent;
c) Output load;
d) Details of any additional circuits to be connected externally;
e) Input impedance;
f) Input signal frequency; and
g) Ambient or reference point temperature.

19. OPEN-LOOP PERFORMANCE (BANDWIDTH)

19.1 Purpose — To measure the bandwidth of the device under test.

19.2 Circuit — The circuit as shown in Fig. 14 shall be used.

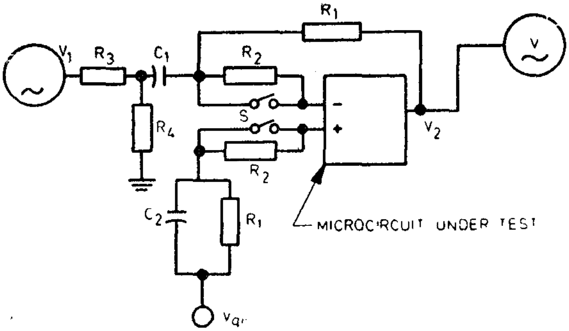


FIG. 14 CIRCUIT FOR MEASUREMENT OF OPEN-LOOP PERFORMANCE

19.3 Description — The apparatus shall consist of a signal generator, ac voltmeter, resistors and capacitors.

Unless otherwise specified, all parameters shall be measured at the minimum and maximum specified ambient operating temperatures and at 25°C ambient.

19.4 Procedure — Establish the amplitude of V_2 within the linear region of the device under test at a frequency specified for the measurement of A_d. Increase the frequency, while maintaining the amplitude of V_1 constant, until V_2 reduces to 0·707 of the original value (3 dB down). This frequency shall be measured as the bandwidth for the device under test.

19.5 Information to be Given in the Relevant Detail Specification:

a) Values of R_1, R_2 and C;

b) Reference or ambient point temperature; and

c) Test temperatures.

20. OPEN-LOOP SMALL-SIGNAL VOLTAGE AMPLIFICATION OF A SINGLE-INPUT AMPLIFIER

20.1 Purpose — To measure the open-loop small-signal voltage amplification of a microcircuit amplifier having a single input terminal at a specified frequency.

20.2 Circuit — The circuit as shown in Fig. 15 shall be used.

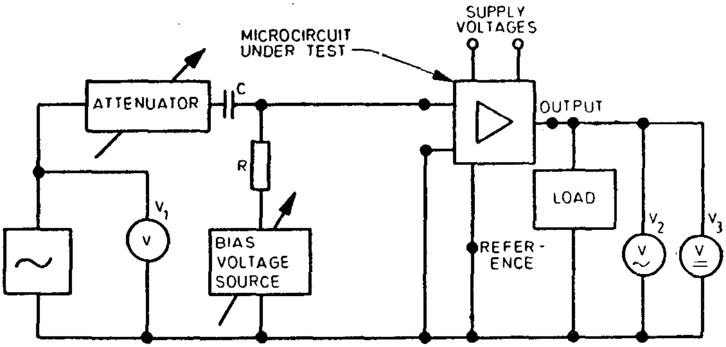


FIG. 15 CIRCUIT FOR MEASUREMENT OF OPEN-LOOP SMALL-SIGNAL VOLTAGE AMPLIFICATION OF SINGLE INPUT AMPLIFIER

20.3 Description — The value of the resistor should be equal to the minimum value of the resistive component of the input impedance of the amplifier.

The capacitor C should offer negligible impedance at the test frequency that is, less than one-hundredth of the input impedance.

The output impedance of the attenuator should be very low compared to the input impedance of the microcircuit (including any associated biasing network), that is preferably less than one-hundredth of the input impedance, or suitable matching arrangements shall be used and taken into account.

Voltmeters V_1 and V_2 may be replaced by a single meter and with suitable switching system.

20.4 Procedure — The temperature conditions are set to the specified values and checked before and after the measurement.

The microcircuit is inserted into the test circuit in accordance with its markings and the supply voltages set to within 1 percent of the specified values.

The bias voltages source is adjusted so that the quiescent level of the output voltages as indicated by V_2 is maintained at the required reference value.

With the attenuator adjusted to give maximum attenuation, the output voltage of the signal generator is adjusted at the required frequency to be equal to the specified reference value of alternating output voltage, which is usually 10 percent or less of the maximum output voltage swing.

The attenuation is then decreased to provide the specified reference value of alternating voltage at the output of the amplifier.

The voltage amplification is then equal to the values of the attenuation.

20.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages;
b) Output reference voltages, both alternating and quiescent;
c) Output load;
d) Details of any additional circuits to be connected externally;
e) Input impedance;
f) Input signal frequency; and
g) Ambient or reference point temperature.

21. COMMON-MODE VOLTAGE AMPLIFICATION

21.1 Purpose — To measure the common-mode voltage amplification of an integrated circuit differential amplifier at a specified frequency.

21.2 Circuit — The circuit as shown in Fig. 16 shall be used.

21.3 Description — The value of each of the resistors *R* should be equal to the minimum value of the resistive component of the input impedance of the amplifier. The capacitor *C* should offer negligible impedance at the test frequency, that is less than one-hundredth of the input impedance.

The output impedance of attenuator 1 should be very low compared to the input impedance of the amplifier (including any associated biasing network), that is preferably less than one-hundredth of the input impedance or suitable matching arrangements shall be used and taken into account. The output impedance of attenuator 2 should also be very low provided that the input impedance to the null detector is very high compared to the load impedance if this is not the case the output impedance of attenuator 2 is to be taken into account when determining the output loading of the amplifier.

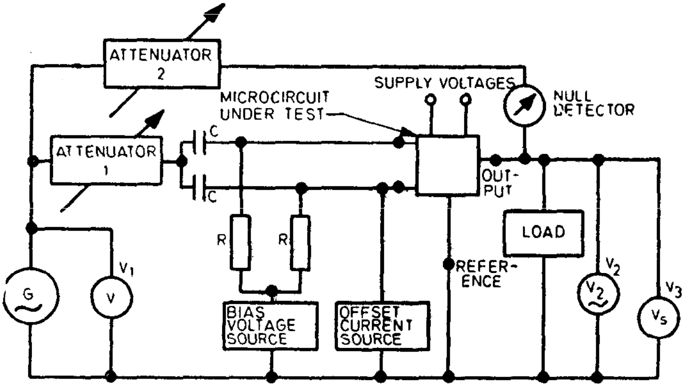


FIG. 16 CIRCUIT FOR MEASUREMENT OF COMMON-MODE VOLTAGE AMPLIFICATION

21.4 Procedure — The temperature conditions are set to the specified value and checked before and after the measurement.

The microcircuit is inserted into the test circuit according to its markings and supply voltages set to within 1 percent of the specified values.

The offset current source is adjusted so that the quiescent value of the output voltage as indicated by V_3 is maintained at the required reference value. With both attenuators adjusted to give maximum attenuation, the signal generator is adjusted at the required frequency so that its output is equal to the specified reference value of alternating output voltages, which is usually 10 percent or less of the maximum output voltage swing. The attenuators 1 and 2 are adjusted until:

a) the required reference value of ac voltage is obtained at the output; and
b) a null is obtained on the null detector.

The common-mode voltage amplification is equal to the difference in the values of the two attenuations. There is a common-mode amplification as the value of attenuator 1 exceeds that of attenuator 2.

NOTE — Usually the output from the generator is equal to the alternating output voltage of the amplifier under test but it will need to exceed the output voltage if a common-mode attenuation is expected.

21.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages;

b) Output reference voltages, both ac and quiescent;

c) Output load;

d) Details of any additional circuits to be connected externally;

e) Input impedance;

f) Input signal frequency; and

g) Ambient or reference point temperature.

22. COMMON-MODE REJECTION RATIO

22.1 Purpose — To measure the rejection ratio of a common-mode input signal to a differential-mode input signal for a micro circuit differential amplifier.

22.2 Circuit — The circuits shown in Fig. 13 and Fig. 16 shall be used.

22.3 Description and Procedure — The differential-voltage amplification and the common-mode voltage amplification are measured as described in **18** and **21** respectively. The common-mode rejection ratio is the ratio of these two amplifications.

NOTE — By using these test methods, the common-mode rejection ratio is being measured with equal input signal levels to the input attenuator, and hence equal output signal levels from the amplifier. This usually gives value equal to or worse than that given by the theoretical definition of equal input signal levels to the amplifier. This method of measurement may be justified since the common-mode signal may be much greater than the differential input signal, and is of greatest concern to the user when the common-mode output level is commensurate with the differential-mode output level.

22.4 Information to be Given in the Relevant Detail Specification: The conditions will be the same as those given in **18.5** and **21.5**.

23. COMMON-MODE INPUT VOLTAGE RANGE

23.1 Purpose — To measure common-mode input voltage range of the device under test.

23.2 Description: Differential Input Amplifier — The test shall be an implied measurement. The maximum common-mode input voltage specified for the amplifier shall be used in making the common-mode rejection ratio test as of **22**.

24. CUT-OFF FREQUENCIES: SMALL-SIGNAL

24.1 Purpose — To determine whether the cut-off frequencies of a microcircuit amplifier under small-signal conditions lie outside specified limits.

24.2 Circuits

24.2.1 For an amplifier having a single input, the circuit of Fig. 15 shall be used.

24.2.2 For an amplifier having differential inputs, the circuit of Fig. 13 shall be used.

24.3 Description — The object of the measurement is to check that the voltage amplification of the amplifier exceeds 0·707 of the mid-band gain at a specified cut-off frequency.

24.4 Procedure — The microcircuit is measured in accordance with the requirements of **18** (for a differential amplifier), or of **20** (for a single input amplifier). The reference value of ac output voltage should not exceed 10 percent of the maximum specified output swing.

The gain is measured at the specified mid-band frequency.

The frequency is then adjusted to be equal to the specified cut-off frequency and the value of the attenuation is reduced to restore the ac output voltage to the original reference value.

The cut-off frequency lies above the upper specified value of cut-off frequency, or below the lower specified value of cut-off frequency, provided the change in the value of attenuation is less than 3 dB.

For direct-coupled microcircuit amplifiers the lower cut-off frequency measurement may be omitted.

24.5 Information to be Given in the Relevant Detail Specification:

Same as given in **18.5** and **20.5**.

25. SMALL-SIGNAL AUDIO-FREQUENCY INPUT IMPEDANCE

25.1 Purpose — To measure the low-frequency input impedance of a linear amplifier integrated circuit under specified conditions.

25.2 Circuit — The circuit as shown in Fig. 17 shall be used.

25.3 Description — Resistor R_1 is a calibrated variable non-reactive resistor. Resistor R_2 should have a high value compared with the output impedance of the attenuator.

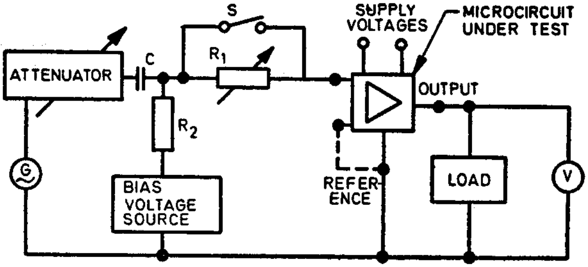


FIG. 17 CIRCUIT FOR MEASUREMENT OF SMALL-SIGNAL AUDIO-FREQUENCY INPUT IMPEDANCE

The capacitor *C* should offer negligible impedance at the frequency of measurement, that is, its impedance should be less than one-hundredth of the input impedance.

The bias conditions should be chosen so that the amplifier is operating within its linear operating region. The attenuator impedance should be very low compared with the input impedance to be measured.

The object of the measurement is to obtain two values of the resistor R_1 which, together with known settings of the attenuator, maintain the output voltage V_0 at a fixed reference level. The input impedance of the circuit may be represented by $R + j_x$ and if V_1 and V_2 are the input voltages at the junction between the attenuator and resistor R_1 to reference and across the input terminals of the circuit respectively, it may be shown that

$$\frac{|V_1|^2}{|V_2|^2} = 1 + \frac{R_1(2R + R_1)}{R^2 + X^2}$$

The values of *R* and *X* may be determined by finding the values of R_1 for known ratios of

$$\frac{|V_1|^2}{|V_2|^2}$$

25.4 Procedure — The ambient or reference point temperature is set to the specified value.

The microcircuit is inserted into the test circuit and the bias and power supplies are increased to the specified values.

With switch *S* closed the signal generator is set to the specified frequency and its output and the attenuator are adjusted to give the specified output voltage V_0 from the circuit under test.

Switch S is opened and the attenuation reduced by 6 dB. The first value of resistor R_1 [$R_{1(1)}$] to give the specified output V_0 is determined.

The attenuation is reduced by a further 6 dB and second value of resistor R_1 [$R_{1(2)}$] to give the specified output V_0 is determined.

The values of the real and imaginary components of the input impedance may be calculated.

If the first, second and third voltages from the attenuator are $V_{1(1)}$, $V_{1(2)}$ and $V_{1(3)}$ respectively.

$$A = \frac{|V_{1(2)}|^2}{|V_{1(1)}|^2}, \text{ and } B = \frac{|V_{1(3)}|^2}{|V_{1(1)}|^2}$$

then

$$R = \frac{R_{1(1)}^2 (A - 1) - R_{1(2)}^2 (B - 1)}{R_{1(1)} (B - 1) - R_{1(2)} (A - 1)}$$

$$R^2 + X^2 = \frac{R_{1(1)} R_{1(2)} (R_{1(2)} - R_{1(1)})}{R_{1(1)}(B - 1) - R_{1(2)}(A - 1)}$$

If only the resistive component is required, the measurement frequency should be low and in this case the value of R_1 after the first 6 dB change is equal to the input resistance.

The base circuit may be modified for the measurement of the input impedance of a differential-mode circuit by inserting a balancing transformer having unity turns ratio with a centre tapped output between the resistor R_1 and the circuit to be measured.

25.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages,
b) Output load;
c) Details of any additional circuits to be connected externally,
d) Reference value of output voltage V_0,
e) Signal generator frequency, and
f) Ambient or reference point temperature.

26. SMALL-SIGNAL OUTPUT IMPEDANCE AT LOW-FREQUENCY

26.1 Purpose — To measure the low-frequency output impedance of a linear amplifier microcircuit under specified conditions.

26.2 Circuit — The circuit as shown in Fig. 18 shall be used.

26.3 Description — Resistor R_1 is a calibrated variable non-reactive resistor. The value of resistor R_2 should be equal to the minimum value of the resistive component of the input impedance of the amplifier.

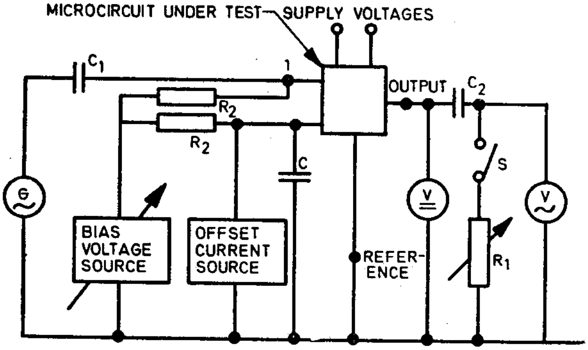


FIG. 18 CIRCUIT FOR MEASUREMENT OF SMALL-SIGNAL OUTPUT IMPEDANCE AT LOW-FREQUENCY

The capacitors C_1 and C_2 should offer negligible impedance at the frequency of the measurement, that is, the impedance should be less than one-hundredth of the input impedance and output impedance respectively.

If the amplifier has only one signal input terminal, the offset current source and its associated resistor should be omitted, and terminal(s) connected directly to the common reference.

The object of the measurement is to obtain two values for resistor R_1 and corresponding values of alternating output voltage for a fixed value of generator input voltage. Then if $V_{o(1)}$ is the value of alternating output voltage with switch S open, and $V_{o(2)}$ is the value of alternating output voltage with S closed and a known value (R_1) for resistor R_1, it may be shown that:

$$\frac{|V_{o(1)}|^2}{|V_{o(2)}|^2} = 1 + \frac{2R}{R_1} + \frac{R^2 + X^2}{R_1^2}$$

where

$R \pm jX$ is the value of the output impedance.

The values of R and X may be determined by finding two values for R_1 for two known ratios of

$$\frac{|V_{o(1)}|^2}{|V_{o(2)}|^2}$$

26.4 Procedure — The ambient or reference point temperature is set to the specified value. The microcircuit is inserted into the test socket and the power supplies adjusted to their specified values. The bias and offset supplies are adjusted to give the specified quiescent reference voltage and the output.

With switch S open, the input generator is set to the specified frequency, and its output level adjusted until the specified reference value of alternating voltage is obtained at the output of the circuit.

Switch S is then closed, and a value of $R_{1(1)}$ is determined for R_1 for which the ac output voltage is reduced by a factor of 2 compared to its no-load value. A second value of $R_{1(2)}$ is then obtained, for which the output voltage is reduced by a further factor of 2.

The values of the real and imaginary components of the output impedance are then obtained by calculation. If the first, second and third output voltages are $V_{o(1)}$, $V_{o(2)}$ and $V_{o(3)}$ respectively,

$$A = \frac{| V_{o(2)} |^2}{| V_{o(1)} |^2}, \text{ and } B \frac{| V_{o(3)} |^2}{| V_{o(1)} |^2}$$

then $$R = \frac{R_{1(1)}{}^2 (A - 1) - R_{1(2)}{}^2 (B - 1)}{R_{1(1)} - R_{1(2)}}$$

and $$R^2 + X^2 = \frac{R_{1(1)} R_{1(2)}}{R_{1(1)} - R_{1(2)}} [R_{1(2)} (B - 1) - R_{1(1)} (A - 1)]$$

If only the resistive component of the output impedance is required, the value of R_1 to give a 2 : 1 reduction in output voltage (with respect to the no-load value), is directly equal to the output resistance.

26.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages;

b) Bias voltage, and where appropriate, offset current;

c) Reference values of no-load output voltage, both quiescent and ac;

d) Details of any additional circuits to be connected externally;

e) Input signal frequency;

f) Value of resistor R_2; and

g) Ambient or reference point temperature.

27. PHASE MARGIN

27.1 Purpose — To measure the phase margin of a device under test.

27.2 Circuit — The circuits as shown in Fig. 19 and Fig. 20 shall be used.

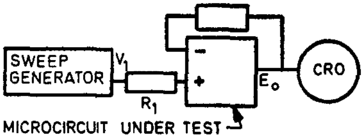


FIG. 19 CIRCUIT FOR MEASUREMENT OF PHASE MARGIN OF NON-INVERTING AMPLIFIER

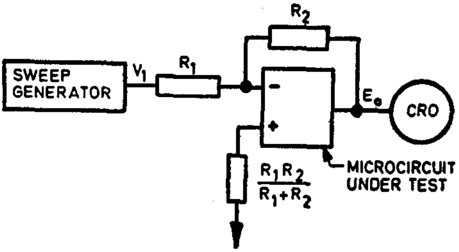


FIG. 20 CIRCUIT FOR MEASUREMENT OF PHASE MARGIN OF INVERTING AMPLIFIER

27.3 Description — This will consist of a video sweep generator, oscilloscope, precision resistors and stabilization network.

Unless otherwise specified, all parameters shall be measured at the minimum and maximum specified ambient operating temperature and at 25°C ambient.

Specified stabilization networks should be added to compensate for the degree of feedback in the test. The circuit under test should have adequate power supply decoupling added. For differential output devices, the measurement described shall be repeated for the other output using the same test circuit except that the cathode ray oscilloscope shall be connected to the other output.

27.4 Procedure — The test shall be set up as in Fig. 19 for a gain of 1 non-inverting. This is the maximum feedback case. R_2 and R_1 shall be the same value and shall be low compared to the amplifier input impedance. Figure 21 shows the amplitude of the envelope of the output E_0. The peaking shall be less then 3 dB (1·414 times the flat band voltage) to indicate a 45° phase margin minimum. The circuit of Fig. 20 shall be used for single ended inverting amplifiers (where no positive input terminal is brought out) or where the test is to be run at closed-loop gains greater than 1. Closed loop gain $= R_2/R_1$. In the case of closed-loop gains greater than one of the peaking shall be less than 3 dB.

27.5 Information to be Given in the Relevant Detail Specification:

a) Values of R_1, R_2 and V_1;
b) Maximum peaking; and
c) Test temperatures.

28. NON-LINEARITY DISTORTION

28.1 Purpose — To measure the variation of small-signal voltage amplification in a wide-band amplifier under specified large-signal conditions.

28.2 Circuit — The circuit as shown in Fig. 22 shall be used.

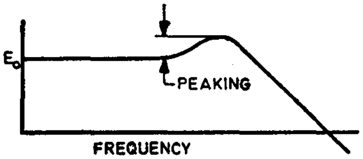


FIG. 21 FREQUENCY RESPONSE

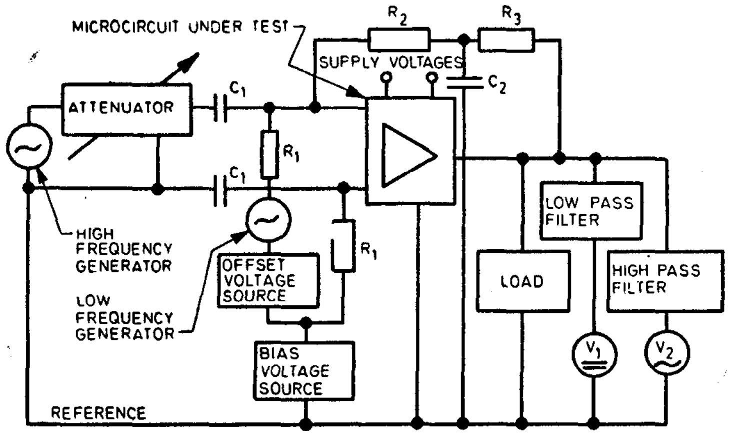


FIG. 22 CIRCUIT FOR MEASUREMENT OF NON-LINEARITY DISTORTION

28.3 Description — Under large-signal conditions distortion occurs due to various types of non-linearity in the amplifier. The small-signal voltage amplification at a high frequency is measured continuously relative to an arbitrary value while the mean (dc) output voltage is varied at a low-frequency through its large signal range. Distortion is shown by a variation in the voltage amplification over this range of output voltage.

The ratio of the high-frequencies to low-frequencies should be greater than 10^4. If used at other than zero frequency, the voltmeters V_1 and V_2 are replaced by a CRO and the intermediate frequency oscillator connected as shown.

The bias voltage shall be zero unless otherwise specified.

The values of the two resistors R_1 together should equal the minimum value of the resistive component of the input impedance of the amplifier. The values of the capacitors C_1 should offer an impedance negligible in comparison with the value of R_1 at the high-frequency but at least an order of magnitude higher than the value of R_1 at the low-frequency. The value of the output impedance of the attenuator shall be low in order to minimize any parasitic coupling between input and output which may lead to oscillation.

The two resistors R_2 and R_3 may be introduced to reduce the effective voltage amplification at low-frequencies but their presence with C_2 shall not affect the performance of the amplifier at high-frequencies and their values shall be such that there is no appreciable loading and any feedback at high frequency is such that it has no effect on the accuracy of measurement.

For single-input amplifiers the bias supply replaces the offset supply and the components associated with the second input are removed.

NOTE — This method is limited to limits of greater than 1 percent.

28.4 Procedure — The ambient or reference point temperature is set to the specified value.

The microcircuit is inserted into the test circuit in accordance with its markings. The supply and bias voltages are set to their specified values. The output voltage is brought to the mean of the specified output voltage range by adjustment of the offset (or bias) voltage.

The high-frequency generator is set to the specified frequency and its attenuator is adjusted until the amplifier gives a peak-to-peak output voltage equal to 10 percent of the specified output range.

The mean output voltage is varied over the specified output range, either by variation of the offset supply or at the low-frequency. The variation in small-signal output amplitude is noted throughout this range.

The non-linearity distortion is given by:

$$\frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} = 100 \text{ percent}$$

28.5 Information to be Given in the Relevant Detail Specification:

a) Supply and bias voltages,
b) Output load,
c) Output voltage range,
d) Frequency of high-frequency generator, and
e) Ambient or reference point temperature.

29. SLEW RATE (PULSED)

29.1 Purpose — To measure the slew rate of the device under test.

29.2 Circuit — The circuit as shown in Fig. 23 shall be used.

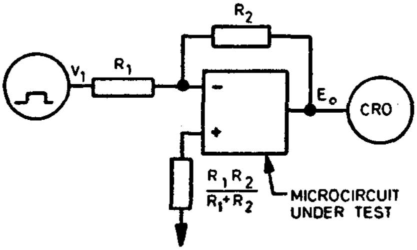


FIG. 23 CIRCUIT FOR MEASUREMENT OF SLEW RATE (PULSED)

29.3 Description — This test will consist of pulse generator, oscilloscope, precision resistors and stabilization network.

Unless otherwise specified, all parameters shall be measured at the minimum and maximum specified ambient operating temperature and at 25°C ambient.

Recommended stabilization networks should be added to compensate for the degree of feedback in the test. The circuit under test should have adequate power supply decoupling added. For differential output devices, the measurement described shall be repeated for the other output using the same test circuit except that the cathode ray oscilloscope shall be connected to the other output.

29.4 Procedure — The pulse amplitude V_1 shall be such that E_0 is the maximum large signal value for the amplifier. With the pulse V_1 having a rise and fall time much faster than the specified slew rate for the amplifier the rise and fall time for the amplifier shall be measured. These shall be within specified limits. The test shall be repeated for both polarities of V_1.

NOTE — This is the preferred technique for slew rate measurement.

29.5 Information to be Given in the Relevant Detail Specification:

a) Values of R_1, R_2 and V_1;

b) Maximum rise time for E_0 positive pulses;

c) Maximum fall time for E_0 positive pulses;

d) Maximum rise time for E_0 negative pulses; and

e) Maximum fall time for E_0 negative pulses.

30. SLEW RATE (SINUSOIDAL)

30.1 Purpose — To measure the slew rate of the device under test.

30.2 Circuit — The circuit as shown in Fig. 24 shall be used.

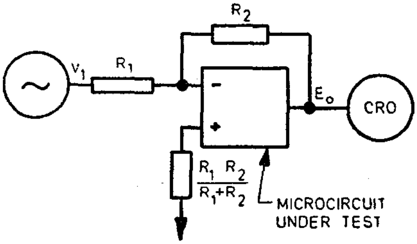


FIG. 24 CIRCUIT FOR MEASUREMENT OF SLEW RATE (SINUSOIDAL)

30.3 Description — This test will consist of signal generator, oscilloscope, precision resistors and stabilization network.

Unless otherwise specified, all parameters shall be measured at the minimum and maximum specified ambient operating temperature and at 25°C ambient.

Recommended stabilization networks should be added to compensate for the degree of feedback in the test. The circuit under test should have adequate power supply decoupling added. For differential output device the measurement described shall be repeated for the other output using the same test circuit except that the cathode ray oscilloscope shall be connected to the other output.

30.4 Procedure — A sinusoidal signal at the input of the circuit under test shall be applied at the specified initial frequency and of sufficient amplitude to cause the circuit output voltage to swing to its maximum values. Maintaining the input signal level constant, increase the frequency from the specified initial frequency to the frequency where the output swing decreases 3 dB. This frequency, converted to units of time, and the swing shall be the measure of slew rate.

30.5 Information to be Given in the Relevant Detail Specification:

a) Values of R_1, R_2 and V_1;

b) Procedure for slew rate and initial frequency when applicable; and

c) Test temperatures.

31. TRANSIENT RESPONSE OF AN OPERATIONAL AMPLIFIER; DELAY TIME; RISE TIME; SETTLING TIME; ACQUISITION TIME; OVERSHOOT

31.1 Purpose — To measure the transient response of an amplifier under small-signal conditions with a specified proportion of negative feedback.

31.2 Circuit — The circuit as shown in Fig. 25 shall be used.

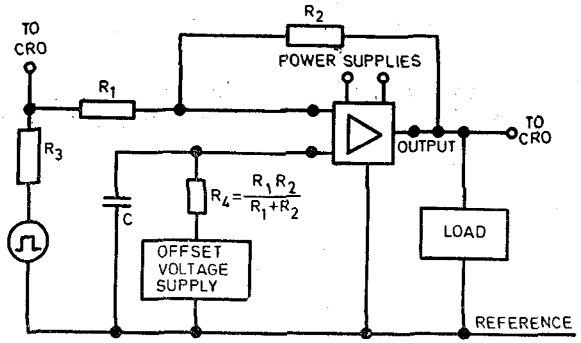


FIG. 25 CIRCUIT FOR MEASUREMENT OF TRANSIENT RESPONSE

31.3 Description — The two resistors R_1 and R_2 should be chosen so that together they produce a time-constant at the input terminal which is negligible compared with the rise time of the microcircuit under tests, whilst ensuring that $R_1 \gg R_5$ and $R_2 \gg R_0$ where R_3 and R_0 are respectively the output resistances of the pulse generator and the microcircuit.

Capacitor C shall offer a negligible impedance at the pulse repetition frequency compared with these resistors.

The measurements shall be made under specified conditions of supply voltage (minimum will usually give the worst case), output loading, input pulse duration and frequency, and specified external elements to give phase compensation. Unless specified otherwise the microcircuit shall be tested with $R_1 = R_2$, that is producing unity gain.

The pulse generator rise and fall times shall be negligible in comparison with the delay time of the microcircuit under test.

The output signal amplitude shall be sufficiently small for the transition times not be limited by the maximum available rate of change of output voltage, that is small-signal conditions apply.

31.4 Procedure — The ambient or reference point temperature is set to the specified value.

The microcircuit is inserted into the test circuit in accordance with its markings. The supply voltages are set to their specified values. The offset voltage is adjusted to bring the output voltage to the reference level.

The pulse generator is set to give the specified pulse duration and frequency and the amplitude is adjusted so that small-signal conditions apply.

The following characteristics may be measured from the output pulse: delay time, rise time, settling time, acquisition time and overshoot, as shown in Fig. 26.

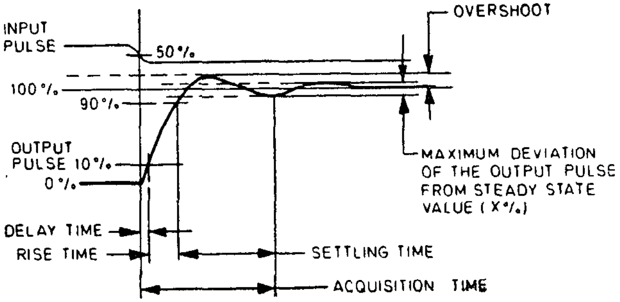


FIG. 26 TYPICAL OUTPUT PULSE

31.5 Information to be Given in the Relevant Detail Specification:

a) Supply voltages,
b) Output load,
c) Values of resistors R_1 and R_2,
b) Details of any additional circuits to be connected externally,
e) Generator frequency and pulse duration, and
f) Ambient or reference point temperature.

APPENDIX A

[*Clause* 3.2.3 (c)]

REFERENCE POINT TEMPERATURE

A-1. PURPOSE

A-1.1 To measure the reference point temperature, case or stud, of a conduction cooled integrated circuit under specified conditions.

A-2. DESCRIPTION

A-2.1 The temperature is measured by means of a thermocouple fitted into a high-conductivity copper spacer inserted between the integrated circuit and the heat sink.

A-2.2 The thermocouple wires should not be greater than 0·25 mm diameter.

A-2.3 The spacer shall be 3 mm thick, of approximately the same size and shape as the mounting base of the device. The disposition and sizes of the holes in the devices, the copper spacer and the heat sink shall be the same.

A-2.4 The thermocouple shall be fixed into a 2 mm diameter holes drilled into the edge of the spacer to the centroid or to within 0·5 mm of the central hole as appropriate.

A-3. PRECAUTIONS

A-3.1 Care should be taken to ensure that the thermocouple is fully inserted into the hole of the spacer. Where a mica washer is used, it should be placed between the spacer and the heat sink.

A-4. PROCEDURE

A-4.1 The temperature is measured under specified conditions by means of the thermocouple.

A-5. SPECIFIED CONDITIONS

A-5.1 The following conditions will be obtained from the detail specification:

a) Test conditions; and

b) Test equipment, if required.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplimentary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	htrtz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2